trasts were instanced. C. H. Hitchcock remarked the importance of northern Maine as a place to decide this question, and mentioned Lake Telos as a promising locality. H. S. Williams again spoke, bringing up the Gaspé section and mentioning facts about northern Maine. J. M. Clarke also remarked his acquaintance with the Devonian fossils from Maine and reaffirmed the finality of the organic tests of correlation.

These papers concluded the session of Thursday. In the evening at 7.30 o'clock the Society assembled at the Hotel Raleigh for the annual banquet. To the delight of all present, Professor Emerson was found at the head of the table, and as usual a very merry evening followed. According to the admirable custom, now well established, the fellows brought their wives, and the ladies gave a brilliant aspect to the dinner. Ninety-five covers were laid, including about 15 for ladies.

J. F. Kemp.

Columbia University.

SCIENTIFIC BOOKS.

Frontinus and the Water Supply of the City of Rome. By Clemens Herschel, Hydraulic Engineer. Boston, Dana Estes & Co. 1899. 4to. xlix + 296 pages.

Frontinus was appointed water commissioner of Rome in 97 A.D., and soon thereafter wrote his two books, generally called De Aquis, on its waterworks. The sole original Latin manuscript, dating from the twelfth or thirteenth century, is preserved in the library of a Benedictine monastery in Italy, and the photographic reproductions of its twenty-four pages which Mr. Herschel gives will be of interest to classical scholars. He also gives the Latin text and its English translation on facing pages, and adds twelve chapters of explanatory and critical matter which are of special value to civil engineers and archæologists; these are accompanied by eighty-four illustrations and three folding plates. This is the first time that De Aquis has appeared in English translation, and it is safe to say that no single volume has ever been published that contains such a wealth of information on the water supply of ancient Rome.

The treatise of Frontinus begins with a description of the nine aqueducts erected prior to 97 A.D., mentioning their builders, sources and lengths. The subject of water measurement is next discussed and the sizes of the standard pipes are given, this being preparatory to determining the amount of water furnished by each aqueduct and how much was used for fountains, for public buildings and for private uses. Then the quality of the waters and the laws for the prevention of pollution receive attention, and this is followed by a statement of the duties and powers of the water commissioners, and of the regulations for preventing the unlawful use of water. Lastly, the methods of repairing the aqueducts are discussed, and the laws for ensuring their proper maintenance are given.

Mr. Herschel discusses at length the engineering and hydraulic feàtures of the aqueducts and of the methods of distributing the water. It is clearly shown that the Roman engineers had no rational methods of measuring water, such quantities as cubic feet per second or gallons per hour being beyond their powers of conception. The unit of measurement used by them was called a 'quinaria,' this being originally a circular pipe whose diameter was $1\frac{1}{4}$ Roman digits, later the number of square units in the cross-section of this circle, and later the quantity of water passing through this area. Evidently it was understood that the discharge through a pipe or channel would vary with the velocity, as Frontinus says that the aqueduct Virgo could not be properly measured near its source, where the current was too slow, but near the city where the velocity was greater he found it to give 2504 quinarias. In general, however, the measurement of water was made by finding the area, in quinarias, of the cross-section of the channel or pipe; thus a denaria pipe, whose diameter was double that of the quinaria pipe, was supposed to discharge four quinarias of water.

The statement is commonly made in cyclopædias that the aqueducts of ancient Rome delivered about 300 gallons of water per day for

each inhabitant, a consumption about three times as great as that of American cities. This statement is traced by Mr. Herschel to certain hypothetical computations published by Prony in 1817, which are shown to rest upon unwarranted assumptions. A probable value of the quinaria is found in three different ways: first, by computations from the measured cross-section of an aqueduct now standing and the ancient slope of its water surface as marked by the incrustations of the deposited limestone; second, by actual gaugings of those ancient aqueducts that are now in use; and third, by computations from reasonable data of the discharge of pipes which delivered water to houses. An analysis of the work of Blumenstihl and Belgrand leads to the conclusion that the value of the quinaria was somewhere between 2500 and 9000 gallons per day. Accepting the statement of Frontinus that 14,000 quinarias were delivered within the city, and calling its population one million, it follows that the consumption was between 35 and 126 gallons per person per day, and when it is considered that one or more of the aqueducts were generally out of service owing to the progress of repairs, the lower figure is probably nearer to the actual consumption. Mr. Herschel's final conclusion is that the probable daily consumption was 38 gallons per person, although the actual value doubtless varied some 20 gallons on either side of that figure.

The Roman laws regarding the injury of aqueducts, the pollution of their waters, and the unlawful use of water have formed the basis of modern statute law for the protection of public water supplies. Regarding the distribution of water to buildings, it is interesting to note that direct connections with the aqueducts and street mains were forbidden; these mains delivered the water to small distributing tanks, and a house connection was made to one of these tanks by a quinaria pipe. It was required by law that this pipe could not be increased in diameter within a distance of fifty feet from the tank, since by so doing the discharge would be increased. These water tanks were under the charge of men called 'aquarii,' who probably bought the water from the city and sold it to consumers, since various methods devised by them to defraud both the city and the consumers are described and severely denounced by Frontinus.

Roman arithmetic and mensuration form the subject of one of Mr. Herschel's interesting chapters, but his statement that Frontinus used for π the value $3\frac{1}{7}$ seems to be scarcely warranted. In fact the list of fractions used by Frontinus does not contain $\frac{1}{7}$, that list being $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{12}$, $\frac{1}{24}$, $\frac{1}{36}$, $\frac{1}{48}$, $\frac{1}{72}$, $\frac{1}{288}$, and multiples of these. From the diameters and circumferences of several pipes, as stated in De Aquis, the writer concludes that the value of π used in computing the latter from the former was probably $3\frac{41}{288}$, or, in the notation of Frontinus, $3 + \frac{1}{12} + \frac{1}{24} + \frac{1}{72} + \frac{1}{288}$.

Mr. Herschel remarks that Frontinus takes high rank, even to-day, as a practical superintendent of waterworks. His first care on assuming the office was to ascertain the history of the aqueducts and the regulations and customs regarding the measurement of the water; then he made gaugings to ascertain the amount of water carried by the aqueducts and the consumption. Finding the latter far less than the former, he traced the discrepancy to unlawful connections. The laws relating to these were then enforced and measures taken to prevent waste. The result was that "the cleanliness of the city is greatly improved, the air is purer, and the causes of pestilence are removed"; at the same time "those who with fear drew water unlawfully, draw their supply now free from care, by grant from the sovereign," and thus morality was promoted.

It is a matter of congratulation that the first English translation of Frontinus' De Aquis should have been made by a hydraulic engineer highly qualified to interpret it. In fact our knowledge of Frontinus and his work is mostly due, not to classical scholars, but to technical men, the French and German translations having been made by the civil engineers Rondelet and Dederich. The writer of a history of Rome, published at Boston in 1886, refers to the book of Frontinus as belonging "to the class which furnish facts without giving ideas." If, however, Frontinus be read carefully by those who are able to understand the facts, as scientists and civil engineers can do, it appears, as the

English translator well says, that many and valuable ideas may be obtained. The interesting commentaries contained in this volume render it possible for even the general reader to do this with pleasure and profit.

MANSFIELD MERRIMAN.

Gleanings from Nature. By W. S. BLATCHLEY. Indianapolis. 1899. 16mo. 348 pp., 15 pl., 100 cuts.

The State Geologist of Indiana has here given us a dozen or more chapters on the natural history of his State, with the laudable purpose of interesting young people in the objects about them. If but a fraction only of the 800,000 children to whom he dedicates the book will read it, the results should be good; for the author speaks at first hand of all he writes, and seems equally at home whether discoursing of quadrupeds, birds, reptiles, fishes, insects, trees, weeds or caverns, to which latter feature of southern Indiana much space is given. We have noticed but one serious error, where the femora of *Mantis* are taken for tibiæ. The stories are simply told, and derive their chief value from being the outcome of close personal contact with nature and from their local flavor. The book is to be heartily recommended to the young people not only of Indiana but of the neighboring states, to which it is nearly as well adapted. It will take them out of doors on every page and awaken a new interest in living nature. The illustrations are mostly good, many excellent and all to the purpose. There is a sufficient index.

S. H. S.

LIVERPOOL MARINE BIOLOGICAL COMMITTEE'S MEMOIRS.

THE appearance of No. I., of the Liverpool Marine Biological Committee's 'Memoirs on Types of British Marine Plants and Animals,' deserves more attention from teachers and students of natural history than the intrinsic scientific value of the volume, however much this may be, can justly claim. This because of the uniqueness in several ways of the series which this number introduces. In the first place these volumes are to be unique in the matter of price. Who has ever before heard of a bound volume, in the English tongue at least, on a natural history subject, written by a distinguished specialist, and containing fifty pages and four good plates, being sold for 37½ cents? Yet that is the price of this first memoir.

It is written by the editor of the series, Professor W. A. Herdman, and the type treated is *Ascidia*, as might be anticipated from the editor's long and distinguished devotion to the group of animals of which this is a representative.

The series again is well-nigh unique in its origin and purpose. What these are may be best shown by extracting a paragraph from the editor's preface.

"In our twelve years, experience of a Biological Station (five years at Puffin Island and seven at Port Erin), where college students and young amateurs formed a large proportion of the workers, the want has been constantly felt of a series of detailed descriptions of the structure of certain common typical animals and plants, chosen as representatives of their groups, and dealt with by specialists. The same want has probably been felt in other similar institutions and college laboratories."

Some twenty other memoirs of like nature and by nearly an equal number of workers are promised.

It is hardly necessary to say that the number before us is scientifically accurate and up to date. It could hardly be otherwise; for its author has himself contributed more than any one else to the making of our knowledge what it is to-day, of the structure and speciography of the Tunicata. No one is better able than he to write such a book, and he has written it as well as he is able to.

The only instances in which I have noticed any doubtfulness or unclearness of statement are in connection with the pericardium and heart, and the coelom. On page 34 we are told that the "pericardial sac and its invagination the heart have formed in the mesoblast between the endostyle and stomach." A reader not already familiar with ascidian embryology would find difficulty, I should think, in harmonizing this statement with the clear statement of the fact found on page 10, viz.: that